# ARTICLE 3

# PROCEDURES FOR BUILDING SYSTEMS

## 3.0 INTRODUCTION

This article sets forth general requirements that apply to all buildings: load path, redundancy, configuration, adjacent buildings, and the condition of the materials.

## 3.1 LOAD PATH

**The structure contains a complete load path for seismic force effects from any horizontal direction that serves to transfer the inertial forces from the mass to the foundation.**

For conforming buildings, the evaluator may consider this condition as mitigated, and no calculations are necessary. The load path is the most essential requirement for a building. There must be a lateral force resisting system that forms a load path between the foundation and all diaphragm levels and that ties all of the portions of the building together. The load path must be complete and sufficiently strong.

## 3.2 REDUNDANCY

**The structure will remain laterally stable after the failure of any single element.**

Check whether stability of the structure depends on a single element. If the failure of a single element (member or connection) will result in loss of lateral stability, the element shall be checked for adequacy using an amplification factor of $C_d/2$, but not less than 1.5. $P$-delta effects shall be included in this check.

## 3.3 CONFIGURATION

**Vertical irregularities** are defined in terms of discontinuities of strength, stiffness, geometry, and mass.

**Horizontal irregularities** involve the horizontal distribution of lateral forces to the resisting frames or shear walls. Irregularities in the shape of diaphragm itself (i.e., diaphragms that are L-shaped or have notches) are covered in Article 7.

**3.3.1 WEAK STORY: Visual observation or a Quick Check indicates that there are no significant strength discontinuities in any of the vertical elements in the lateral-force-resisting system; the story strength at any story is not less than 80 percent of the strength of the story above.**

For buildings designed and constructed in accordance with the 1989 or later editions of Part 2, Title 24, the evaluator may consider this condition as mitigated, and no calculations are necessary. Check story strengths individually. Where a weak story exists, the resisting elements shall be checked; include $P$-delta effects and inelastic demand. To compensate for the concentration of inelastic action where the story strength of the weak story is less than 65 percent of the story above, amplify the design forces in the weak story by the factor $C_d/2$, but not less than 1.5. Conforming buildings which fail this check shall be placed in SPC 4.

**3.3.2 SOFT STORY: Visual observation or a Quick Check indicates that there are no significant stiffness discontinuities in any of the vertical elements in the lateral-force-resisting system; the lateral stiffness of a story is not less than 70 percent of that in the story above or less than 80 percent of the average stiffness of the three stories above.**

For buildings designed and constructed in accordance with the 1989 or later editions of Part 2, Title 24, the evaluator may consider this condition as mitigated, and no calculations are necessary. The deficiency is in the stiffness of certain portions of the building. Where a soft story condition is indicated, the stiffness of the building shall be calculated story by story, in order to determine whether a story falls within the definition of a soft story. Where a soft story exists, the resisting elements shall be checked; include *P*-delta effects. For buildings more than 65 feet or five stories tall, a dynamic analysis shall be performed to compute the distribution of seismic forces.

**3.3.3 GEOMETRY: There are no significant geometrical irregularities; there are no setbacks (i.e., no changes in horizontal dimension of the lateral-force-resisting system of more than 30 percent in a story relative to the adjacent stories).**

For buildings designed and constructed in accordance with the 1989 or later editions of Part 2, Title 24, the evaluator may consider this condition as mitigated, and no calculations are necessary. Where geometric irregularities exist, a dynamic analysis shall be performed to compute the vertical distribution of seismic forces.

**3.3.4 MASS: There are no significant mass irregularities; there is no change of effective mass of more than 50 percent from one story to the next, excluding light roofs.**

For buildings designed and constructed in accordance with the 1989 or later editions of Part 2, Title 24, the evaluator may consider this condition as mitigated, and no calculations are necessary. The deficiency is in the distribution of mass in the building. The effective mass is the real mass consisting of the dead weight of the floor plus the actual weights of partitions and equipment. Where mass irregularities exist, a dynamic analysis shall be performed to compute the vertical distribution of seismic forces.

**3.3.5 VERTICAL DISCONTINUITIES: All shear walls, infilled walls, and frames are continuous to the foundation.**

For buildings designed and constructed in accordance with the 1989 or later editions of Part 2, Title 24, the evaluator may consider this condition as mitigated, and no calculations are necessary. The primary deficiency is in the strength of the columns that support the wall or frame. The secondary deficiency is in the strength of the connecting strut or diaphragm. Conforming buildings which fail these checks shall be placed in SPC 4.

**Procedure for columns:** Check the columns that support the upper vertical lateral load-resisting element for their capacity to support the gravity loads plus the overturning forces. The overturning forces shall be based on the design forces amplified by the factor $C_d/2$, but not less than 1.5, or on the capacity of the vertical lateral load-resisting element to resist lateral force if this is greater. The column check shall include *P*-delta effects.

**Procedure for strut or diaphragm:** Check the strut or diaphragm for its ability to transfer the load from the discontinuous element to the lower resisting element.

**3.3.6 TORSION: The lateral-force-resisting elements form a well balanced system that is not subject to significant torsion. Significant torsion will be taken as any condition where the distance between the story center of rigidity and the story center of mass is greater than 20 percent of the width of the structure in either major plan dimension.**

For buildings designed and constructed in accordance with the 1989 or later editions of Part 2, Title 24, the evaluator may consider this condition as mitigated, and no calculations are necessary. One deficiency is in the layout and the strengths and stiffness of the walls and frames of the lateral-force-resisting system. Another deficiency is in the strength of columns that are not part of the lateral-force-resisting system but are forced to undergo displacements due to the rotation of the diaphragm. Verify the adequacy of the system by analyzing the torsional response using procedures that are appropriate for the relative rigidities of the diaphragms and the vertical resisting elements. Calculate the maximum story drift (the average building drift plus the additional displacement due to torsion). Verify that all vertical load carrying elements can maintain their load carrying ability under the expected drifts. When checking columns, include *P*-delta effects and consider inelastic demand. Conforming buildings which fail this check shall be placed in SPC 4.

## 3.4 ADJACENT BUILDINGS

**There is no immediately adjacent structure that is less than half as tall or has floors/levels that do not match those of the building being evaluated. A neighboring structure is considered to be "immediately adjacent" if it is within 2 inches times the number of stories away from the building being evaluated.**

The deficiency is the distance between the buildings. Report the condition as a hazard. Where both buildings are designed and constructed in accordance with the 1989 or later editions of Part 2, Title 24, the evaluator may consider this condition as mitigated. Other conforming buildings which fail these checks shall be placed in SPC 4.

## 3.5 DEFLECTION INCOMPATIBILITY

**Column and Beam Assemblies that are not part of the lateral force-resisting system (i.e. gravity load-resisting frames) are capable of accommodating imposed building drifts, including amplified drift caused by diaphragm deflections, without loss of vertical load carrying capacity.**

For conforming buildings, the evaluator may consider this condition as mitigated, and no calculations are necessary. The deficiency is in the ductility of vertical-load carrying system. Calculate the expected drifts using the procedures in Section 2.4.4. Use net section properties for all reinforced concrete elements in the lateral force resisting system. Include the lateral displacements due to diaphragm deflections, using the diaphragm loading computed in Section 2.4.6. Evaluate the capacity of the non-lateral -force-resisting columns and beam assemblies to undergo the combined drift, considering moment-axial force interaction and column shear.

## 3.6 SHORT ACAPTIVE@ COLUMNS

**There are no columns with height-to-depth rations less than 75% of the nominal height-to-depth ratios of the typical columns at that level.**

The deficiency is in the tendency of short captive columns to attract high shear forces because of their high stiffness relative to adjacent elements. Calculate the story drift, and determine the shear demand ($V_e$) in the short column caused by the drift ($V_e$=2M/L). The ratio of $V_e/V_n$ shall be less than one, where $V_n$ is the column nominal shear capacity computed in accordance with ACI criteria. Conforming buildings which fail these checks shall be placed in SPC 4.

## 3.7 EVALUATION OF MATERIALS AND CONDITIONS

**3.7.1 DETERIORATION OF WOOD: None of the wood members shows signs of decay, shrinkage, splitting, fire damage, or sagging and none of the metal accessories is deteriorated, broken, or loose.**

The deficiency is in the capacity of the deteriorated elements. Determine the cause and extent of damage. Identify the lateral-force-resisting system and determine the consequences of the damage to the system. The system shall be judged adequate if it can perform with the damaged elements. Check the structural systems with appropriate reductions in member properties.

**3.7.2 OVERDRIVEN NAILS: There is no evidence of overdriven nails in the shear walls or diaphragms.**
The deficiency is in the capacity of the fasteners. Check the wall demand and capacity, using reduced strength due to overdriven fasteners.

**3.7.3 DETERIORATION OF STEEL: There is no significant visible rusting, corrosion, or other deterioration in any of the steel elements in the vertical- or lateral-force-resisting systems.**

The deficiency is the reduction in cross-section of the elements. Check the structural systems with appropriate reductions in member properties. See Article 4 for inspection requirements for welded steel moment resisting frame structures.

**3.7.4 DETERIORATION OF CONCRETE: There is no visible deterioration of concrete or reinforcing steel in any of the frame elements.**

The deficiency is the reduction in member properties. Check the structural systems with appropriate reductions in member capacities.

**3.7.5 POST-TENSIONING ANCHORS: There is no evidence of corrosion or spalling in the vicinity of post-tensioning or end fittings. Coil anchors have not been used.**

The deficiency is the reduced area of the prestress strands, and, with coil anchors, the ability of the anchorage to maintain its grip under cyclic loading. Inspect a sample of the concrete in the area of the anchorage to determine its condition. Determine the cause and extent of the deterioration. Consider the effects of anchorage failure on the vertical and lateral load carrying capacity of the structure.

**3.7.6 CONCRETE WALL CRACKS: All diagonal cracks in the wall elements are 1.0mm or less in width, are in isolated locations, and do not form an X pattern.**

The deficiency is the reduced capacity of the wall. Determine the cause and extent of the cracking. Check the structural systems with reduced wall capacity.

**3.7.7 CRACKS IN BOUNDARY COLUMNS: There are no diagonal cracks wider than 1.0 mm in concrete columns that encase the masonry infills.**

The deficiency is the reduced capacity of the wall. Evaluate the wall with limited capacity assigned to the deteriorated elements. Determine the cause and extent of the damage.

**3.7.8 PRECAST CONCRETE WALLS: There is no significant visible deterioration of concrete or reinforcing steel or evidence of distress, especially at the connections.**

The deficiency is in the strength of the connections. Determine the cause and extent of distress and check the structural systems with appropriate reductions in capacity.

**3.7.9 MASONRY JOINTS: The mortar cannot be easily scraped away from the joints by hand with a metal tool, and there are no significant areas of eroded mortar.**

The deficiency is in the strength of the wall. Check the adequacy of the walls with the strength determined by tests. This evaluation statement also applies to masonry veneers present on the exterior or interior walls of the building.

**3.7.10 MASONRY UNITS: There is no visible deterioration of large areas of masonry units.**

The deficiency is in the strength of the units. Determine the cause and extent of deterioration and use reduced capacity in determining the adequacy of the units.

**3.7.11 CRACKS IN INFILL WALLS: There are no diagonal cracks in the infilled walls that extend throughout a panel or are greater than 1.0 mm wide.**

The deficiency is the reduced capacity of the wall. Determine the cause and extent of the cracking. If appropriate, check the structural systems with reduced wall capacity.